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SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING APRIL, 1917.

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[Dated: Washington, D. C., May 25, 1917.]

For a description of instrumental exposures and an account of the methods of obtaining and reducing the measurements the reader is referred to the REVIEW for January, 1917, 45:2.

The monthly means and departures from normal values in Table 1 show that during April, 1917, direct solar radiation averaged below normal intensity at Washington, D. C., and Santa Fe, N. Mex., slightly above normal at Madison, Wis., and very close to normal at Lincoln, Nebr. There were comparatively few clear days at any of the stations, and the series obtained at Madison on the afternoon of the 6th and the morning of the 13th are the only two that are good enough to permit of extrapolation to zero air mass. These two series give 1.96 and 1.81, respectively, for the value of the solar constant.

Table 3 shows only unimportant departures from normal radiation at Washington, a deficiency of nearly 8 per cent at Madison, and of 20 per cent at Lincoln.

Skylight polarization measurements at Washington give a mean of 56 per cent, with a maximum of 66 per cent on April 10; and at Madison, a mean of 57 per cent, with a maximum of 67 per cent on the 13th. These are very close to average values for April.

TABLE 1.—Solar radiation intensities during April, 1917.

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	
Apr. 4	1.21	1.12									
7	1.35										
9	1.44	1.26									
10	1.40	1.17	0.86	0.78	0.72	0.68	0.63	0.57			
11	1.02	0.83	0.71	0.63	0.55						
14	0.97	0.98									
16	1.10				0.88						
17	0.92	0.81	0.67	0.53							
23	1.24	1.13	1.00	0.88	0.78	0.72	0.57				
27	0.99										
30	1.00	0.86	0.72	0.58	0.51	0.46	0.41	0.38			
Monthly means.	1.33	1.11	1.00	0.79	0.66	0.68	0.57	(0.52)	(0.48)		
Departure from 9-year normal.	-0.04	-0.03	-0.05	-0.15	-0.20	-0.12	-0.14	-0.19	-0.19		
P. M.											
Apr. 3	1.41	1.27									
10	1.20	0.79	0.66	0.56	0.48		0.37	0.35			
Monthly means.	(1.30)	(1.03)	(0.66)	(0.56)	(0.48)		(0.37)	(0.35)			
Departure from 9-year normal.	+0.22	+0.03	-0.23	-0.27	-0.21		-0.13				

TABLE 1.—Solar radiation intensities during April, 1917—Continued.

Madison, Wis.

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	
Apr. 2	1.57	1.45									
6	1.55	1.44			1.37	1.28					
9		1.35									
12					1.16	1.07	0.92				
13	1.51	1.42	1.34	1.25							
21	1.35	1.19	1.15	1.11	1.03	0.96	0.89				
Monthly means.	1.50	1.37	1.26	1.18	1.05	(1.06)	(1.00)				
Departure from 7-year normal.	+0.12	+0.04	+0.04	+0.05	-0.05	-0.04	-0.04				
P. M.											
Apr. 6	1.43	1.33	1.23	1.14							
13	1.40										
21	1.19										
Monthly means.	1.34	(1.33)	(1.23)	(1.14)							
Departure from 7-year normal.	+0.06	+0.11	+0.10	+0.04							

Lincoln, Nebr.

Date.	Lincoln, Nebr.										
	A. M.	1.62	1.46	1.31	1.20	1.07	1.00	0.95	0.89	0.81	
	1.61	1.46	1.32	1.20	1.08	1.00	0.95	0.86	0.76	0.60	
Apr. 8	1.62	1.43	1.26	1.17	1.03	0.93	0.87	0.80	0.72		
9	1.61	1.46	1.32	1.20	1.08	1.00	0.95	0.86	0.76		
21	1.38	1.16	1.12	0.93	0.71	0.65					
Monthly means.	(1.62)	1.43	1.26	1.17	1.03	0.93	0.87	0.80	0.72		
Departure from 2-year normal.	+0.07	+0.02	±0.00	+0.02	-0.02	-0.03	±0.00	-0.05	±0.00		
P. M.											
Apr. 18	1.01	0.87	0.79	0.67							
Monthly means.	(1.01)	(0.87)	(0.79)	(0.67)							
Departure from 2-year normal.	-0.11	-0.14	-0.14	-0.18							

Santa Fe, N. Mex.

Date.	Santa Fe, N. Mex.										
	A. M.	1.41	1.41								
	1.43	1.37	1.29	1.24	1.20						
	1.41	1.34	1.20								
	1.41	1.26	1.22	1.20	1.15	1.11	1.06	1.05			
	1.41	1.20	1.11	1.03	0.97	0.92	0.87	0.82	0.77		
	1.44				1.15	1.10	1.07				
Monthly means.	1.44	1.40	1.30	1.19	1.16	1.11	1.06	1.02	0.95	(0.77)	
Departure from 5-year normal.	-0.09	-0.03	-0.11	-0.06	-0.04	-0.04	-0.04	-0.02	-0.02		
P. M.											
Apr. 20	1.27	1.16	1.08	1.00	0.93						
21	1.09	1.02	0.95								
25	1.18	1.06									
30	1.18	1.05	0.98	0.93							
Monthly means.	1.21	1.09	1.03	0.96	(0.93)						
Departure from 9-year normal.	+0.22	+0.03	-0.23	-0.27	-0.21	-0.13					

TABLE 2.—Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Dates.	A. M.	P. M.	Dates.	A. M.	P. M.	Dates.	A. M.	P. M.	Dates.	A. M.	P. M.
1917.	mm.	mm.	1917.	mm.	mm.	1917.	mm.	mm.	1917.	mm.	mm.
Apr. 3	4.17	2.62	Apr. 2	2.74	3.00	Apr. 8	3.15	3.63	Apr. 6	2.26	1.96
4	4.57	4.75	6	2.62	2.87	9	3.45	4.57	7	1.52	1.52
7	4.37	3.30	9	2.74	5.36	18	7.29	10.21	20	2.36	1.60
9	3.30	2.36	12	4.37	3.63	21	5.16	5.16	21	3.00	1.19
10	2.16	2.74	13	1.68	3.30				23	1.78	2.62
11	2.08	3.98	21	4.75	6.02				24	2.74	1.96
14	2.87	3.30							25	3.81	3.99
16	3.45	4.37							26	3.15	2.06
17	4.57	5.16							30	3.81	2.16
23	9.14	9.47									
27	4.57	7.20									
30	9.14	9.88									

TABLE 3.—Daily totals and departures of solar and sky radiation during April, 1917.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
Apr. 1	calories.	calories.	calories.	calories.	calories.	calories.	calories.	calories.	calories.
2	487	77	308	100	-307	-73	100	-307	-73
3	299	535	385	-91	149	1	9	-158	-72
4	539	317	203	147	-71	-180	156	-229	-252
5	538	158	147	144	-232	-237	300	-461	-489
6	64	167	460	-332	-225	75	-32	-686	-414
7	202	595	358	-197	200	-27	-229	-486	-441
8	280	631	551	-124	231	164	-40	-602	-763
9	596	529	522	189	126	134	25	-245	-465
10	618	513	425	208	108	36	233	-137	-429
11	589	524	336	177	116	-54	410	-21	-483
12	358	539	508	-57	128	117	353	107	-366
13	167	621	371	-251	207	-20	102	314	-386
14	598	418	493	178	1	101	280	315	-285
15	420	559	60	-3	139	-333	277	454	-618
16	606	186	249	180	-236	-144	457	218	-762
17	522	497	305	94	72	-89	551	290	-851
18	476	325	408	45	-103	13	596	187	-838
19	422	292	305	-12	-138	-90	584	49	-928
20	430	394	245	-7	-39	-151	577	10	-1,079
Decade departure.....							344	147	-650
21	388	601	527	-51	166	130	526	176	-949
22	587	440	509	145	2	111	671	178	-838
23	558	480	428	113	40	30	784	218	-808
24	448	562	232	1	120	-167	785	338	-975
25	232	104	438	-218	-340	38	567	-2	-937
26	106	392	91	-347	-64	-309	220	-66	-1,246
27	502	549	76	46	102	-325	266	36	-1,571
28	134	274	46	-324	-175	-356	-58	-139	-927
29	266	77	234	-195	-374	-160	-233	-513	-2,046
30	574	103	160	110	-350	-244	-143	-863	-2,340
Decade departure.....							-720	-873	-1,261
Excess or deficiency [calories.....] since first of year.....	[Per cent.....]						-1,500	+675	-2,708
							-4.2	+1.9	-7.2

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EQUATION OF HORIZONTAL RAINBOWS.¹

(Paper read before the Tokyo Mathematico-physical Society, Jan. 20, 1917.)

By KOKICHI OTobe.

1. The subject of this paper was suggested to me when the horizontal rainbows were being demonstrated [*cf. MONTHLY WEATHER REVIEW*, Jan., 1917, 45:5]. My object is:

(a) To deduce the general equation of the horizontal rainbows due to a source of light at a finite distance from the observer.

(b) To show that the curves are not in general the conic sections;

(c) But when the straight line passing through the source and the observer's eye is perpendicular to the plane sheet of fine water drops, the curves become concentric circles.

(d) To verify the general equation by deducing some special cases actually observable with parallel rays of the sun.

(e) To confirm the above results by experiment.

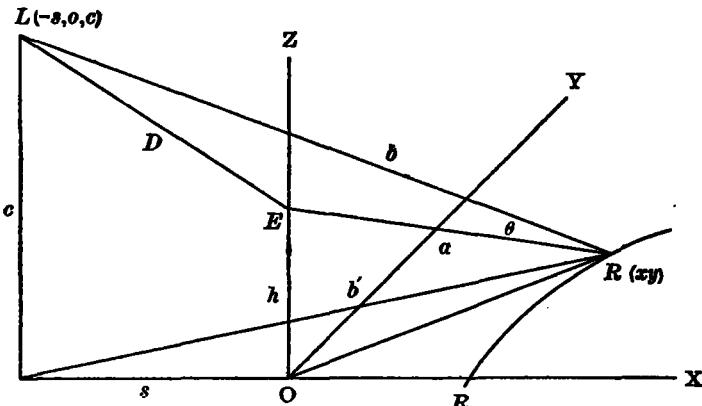


FIG. 1.

2. Let the rectangular coordinate axes be drawn as in figure 1, $(-s, 0, c)$, $(0, 0, h)$ and $(x, y, 0)$ being the coordinates of a source of light, L , of an observer's eye E , and of a point R in the arc R_0R of the rainbow, respectively.

And let θ denote the angle between the incident ray LR and the effective ray RE .

Then we obtain from the triangle ERL ,

$$D^2 = a^2 + b^2 - 2abc \cos \theta \quad (1)$$

where

$$\begin{aligned} a^2 &= h^2 + r^2 \\ b^2 &= c^2 + b'^2 \\ b'^2 &= (s+x)^2 + y^2 \\ r^2 &= x^2 + y^2 \end{aligned} \quad (2)$$

Substituting (2) in (1), and remembering the relation

$$D^2 = (c-h)^2 + s^2,$$

$$D^2 = c^2 - h^2 - s^2 = -2ch,$$

we have

$$(ch + r^2 + s^2 + y^2)^2 = (h^2 + x^2 + y^2)(c^2 + s^2 + x^2 + y^2 + 2xs) \cos^2 \theta, \quad (3)$$

as the required equation.

The curve is symmetrical about the axis of X , but not so simple as to be traced. Since the equation contains the angle θ and the coordinates of the eye, E , the position of the rainbow will be different as we look with the right eye or with the left. This was actually the case even with the horizontal rainbow observed on the surface of the moat.

3. When both the source of light, L , and the observer's eye, E , are in the Z axis, we may put $s=0$, so that we have from (3)

$$(ch + r^2)^2 = (c^2 + r^2)(h^2 + r^2) \cos^2 \theta,$$

hence

$$(ch + r^2)^2 \sin^2 \theta = [(c^2 + r^2)(h^2 + r^2) - (ch + r^2)^2] \cos^2 \theta, \\ = (c-h)^2 r^2 \cos^2 \theta,$$

therefore

$$ch + r^2 = \pm (c-h)r \cot \theta.$$

The plus or minus sign should be taken according as $c > h$ or $c < h$.

¹ Reprinted from Jour. Meteorol. Soc. Japan, Feb., 1917, 36: 7-14.